

# Spatial Data Infrastructures for Environmental E-government Services: the case of Water Abstractions Authorisations

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## Abstract

Environment-related authorisations are a relevant issue for environmental management. They require a considerable effort by the authorities, and this might result in substantial delays for the citizens. Implementing those authorisation processes by means of e-government services would improve efficiency and, consequently, citizen satisfaction. Environment-related authorisations usually require a variety of geospatial information, and have to deal with administrative areas which do not match physical and ecological ones. They also have to integrate heterogeneous information in different formats, data models and languages, and provided by distinct organisations, even from different countries. This paper discusses how Spatial Data Infrastructures (SDIs) can deal with these problems in the environmental domain, while improving the level of service provision in terms of e-government applications. This is even more relevant within the European Union where there is a legal mandate to establish an SDI to support environmental policies and activities with an impact on the environment. As a proof-of-concept, an application to request and manage water abstraction authorisations, based on an SDI, is demonstrated. This application is part of SDIGER, a cross-border inter-administration SDI to support the water framework directive information access for the Adour–Garonne and Ebro River basins, that was a pilot project for the EU INSPIRE Directive. The introduction of this transactional e-government service modifies the administrative process of granting authorisations: it allows to re-use the effort in data capture made by the applicants in their requests, facilitates the submission of more feasible applications and reduces the workload of the office staff.

**Keywords:** e-government, Spatial Data Infrastructures, INSPIRE, Water

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## 1. Introduction and motivation

In recent years, the number and quality of e-government services provided by public authorities have experienced a huge increase. This is mainly due to the fact that many countries are implementing e-government policies, strategies and programs (Ancarani, 2005; Department of Economic and Social Affairs Division for Public Administration and Development Management, 2008; Capgemini et al., 2009).

However, environment-related permits are among the least developed e-government services in Europe (Capgemini et al., 2010, 2009). In the case of these permits, and in contrast with many other e-government services, geospatial data play an important role. Geospatial information is generally difficult to create, maintain, and exploit; it is expensive, and presents scale, resolution, thematic and jurisdictional problems when used (Molenaar, 2006a,b). Besides this, environmental information usually has the additional problem that “environmental boundaries” (e.g. ecosystems, hydrographical watersheds and hydrogeological bodies) do not match administrative areas. Public authorities, which are the main creators and users of geospatial information (Brown and Brudney, 1998; Nogueras-Iso et al., 2004), require the use of geospatial information from controlled sources and trusted quality for the implementation of e-government services (Molenaar, 2006a,b). Environmental geospatial information in particular affects many issues related to human health and safety, so it is crucial that it has good quality and comes from controlled sources.

Currently, the framework for the optimisation of the creation, maintenance and distribution of public geographic information is being provided by *Spatial Data Infrastructures* (SDIs) (Nogueras-Iso et al., 2005; Nebert, 2004). SDIs can be considered part of e-government frameworks dealing with the geographic aspects of e-government services (de Vries, 2007; Georgiadou et al., 2006). They are enabling government agencies to meet the challenges to reduce costs, deliver services faster, provide better customer services, and increase productivity. However, in spite of the existence of SDI initiatives in many countries, the level of maturity or sophistication of e-government services is not improving in those areas that require geospatial information, such as environmental management (Andersen and Henriksen, 2006). In this paper, we define *level of maturity or sophistication of e-government services* as the level of service provision to citizens, business or other governments in terms of complexity and completion of the electronic services and procedures offered; definition based on the works by Layne and Lee (2001); Moon (2002); and Andersen and Henriksen (2006).

In this paper, the authors analyse how SDIs can provide elements and mechanisms at different levels of e-government maturity and how, in the case of the European Union, the obligations of environment and water related directives such as INSPIRE (Infrastructure for Spatial Information in the European Community) and the Directive on Public Access to Environmental Information (Eu-

European Parliament and Council, 2003a) offer opportunities to provide better e-government services. The analysis is illustrated with a proof-of-concept: an e-government service to support the administrative process to apply for and grant water abstraction authorisations within a European water authority and built on top of SDIs. This service, whose technical aspects were presented by Latre et al. (2010), was envisioned as part of SDIGER (Zarazaga-Soria et al., 2007), a pilot project on the implementation of INSPIRE funded by the Statistical Office of The European Communities.

The rest of the paper is structured as follows. The next section deals with the relation among geospatial information, SDIs and spatial data initiatives in the European context. Section 3 analyses and discusses the relation between e-government services in the environmental domain and SDIs. Section 4 shows how e-government services can be developed using components of an SDI, presenting the example of an application that implements a process to request water abstraction authorisations. Finally, in section 5, the results of this work are discussed and some conclusions are drawn.

## 2. Background

### 2.1. *Geospatial data and Spatial Data Infrastructures*

Geospatial data, that include references to locations on Earth, are a requirement in many environmental management processes. Nowadays, more and more geospatial data are being gathered and made available by different institutions and companies (Goodall et al., 2008; Giuliani et al., 2011). This is due to several factors such as the increasing number of sensors at monitoring sites, technological advances in high-resolution satellite imagery, or the wide availability of GPS data.

Despite this increase in geospatial data availability, their use and management is still more complex (due to diversity and volume) when compared to other kinds of data (Di et al., 2008), so the need for effective data access, sharing, and processing becomes increasingly important. Not surprisingly, the main creators and users of geographic information are public authorities (Brown and Brudney, 1998; Noguera-Iso et al., 2004). These public authorities need those data to come from well-known sources and to be of good quality (Molenaar, 2006a).

SDIs provide a platform for the distribution of geographic information (e.g. environmental data), at different organisational levels (local, national, regional and global) involving both public and private institutions (Nebert, 2004; Noguera-Iso et al., 2005). SDIs are composed of spatial datasets, metadata and services; agreements on sharing, access and use; and coordination mechanisms (European Parliament and Council, 2007). Discovery, access and distribution of up-to-date information are achieved by means of standard web services. Ideally, this should be done at any government agency that has the responsibility of creating and maintaining geographic information.

## 2.2. Related European directives

In the field of SDIs, the European Union approved the INSPIRE Directive (*IN*frastructure for *S*patial *I*nfoRmation in *E*urope) in 2007 (European Parliament and Council, 2007). INSPIRE is an ambitious legislative directive whose aim is the creation of a European SDI in order to support Community environmental policies, and other policies or activities which may have an impact on the environment. The European SDI is developed hierarchically, i.e. it is based on the infrastructures established and operated by the Member States. In the same way, these national SDIs could be built including other infrastructures developed at sub-national levels, also as a hierarchy (Rajabifard et al., 2000, 2003) or as a connected network (Vandenbroucke et al., 2009).

Besides INSPIRE, a number of different initiatives and pieces of legislation in the environmental field are being adopted in the European Union with a strong focus on environmental data. One of them is the directive on public access to environmental information (European Parliament and Council, 2003a), which states that “[i]ncreased public access to environmental information and the dissemination of such information contribute to a greater awareness of environmental matters, a free exchange of views, more effective participation by the public in environmental decision-making and, eventually, to a better environment”. Public authorities should make available and disseminate environmental information to the general public to the widest extent possible. The directive on the re-use of public sector information (European Parliament and Council, 2003b) deals with the same idea, extending the scope of it to the whole set of public sector information (with some exceptions) and with a strong emphasis on fair, proportionate and non-discriminatory conditions for the re-use of public sector information for both commercial and non-commercial purposes (Janssen, 2011).

Another piece of European environmental legislation, closely related to the example presented in section 4, is the Water Framework Directive (WFD) (European Parliament and Council, 2000). The main objective of this directive is the achievement of a *good state* for all the European waters by 2015 using a management based on river basins, not on administrative boundaries. Managing basins is a problematic issue not only at international level, but also within countries where several government agencies share responsibilities on the administration of hydrological areas. It is considered the most important and complete piece of legislation in this respect (Letcher and Giupponi, 2005): a *Common Implementation Strategy* (CIS) was designed for its execution, and additional directives, like the directive on groundwater (European Parliament and Council, 2006a) and the directive on the discharge of dangerous substances (European Parliament and Council, 2006b), have had to be developed to fulfil some of the requirements it poses. Not only in the environmental domain has it been demanding, but also in the field of environmental information systems, that have been heavily influenced by the need to support the processes of the WFD (Usländer, 2005). The requirements on public information and consultation that the 14th article of the WFD establishes are further developed in the *Guidance on Public Participation in Relation to the Water Framework Directive*

(European Commission, 2002) and the *Guidance for reporting under the Water Framework Directive* (European Commission, 2009a), that consider information supply as the base to support consultation and active involvement in the management of the river basin by the general public, stakeholders and other authorities. In addition, the *Guidance Document on Implementing the GIS Elements of the Water Framework Directive* (Vogt, 2002) and the *Updated Guidance on Implementing the Geographical Information System (GIS) Elements of the EU Water policy* (European Commission, 2009b) recommend the use of INSPIRE to communicate data among the Member States and the European Commission and to disseminate this information to the public.

### 2.3. E-government maturity models

Considering the fact that SDIs form part of e-government frameworks dealing with geospatial data (Georgiadou et al., 2006; de Vries, 2007), it is worth to review the concepts of *e-government* and *maturity level* of e-government. Since there is not a clear definition of e-government (Yildiz, 2007; Halchin, 2004), we will use the definition given by (Holden et al., 2003): “the provision of governmental information and services electronically 24 hours per day, 7 days per week”. Services to be provided include, for example, e-taxing (income, corporate or VAT taxes), e-ID (obtaining personal documentation) or e-procurement (tendering for public procurement). Several models have been proposed to characterise e-government levels of maturity and sophistication. Most of them present incremental stages of maturity, where their main differences can be found at the higher levels. The Layne and Lee (2001) model is, according to Andersen and Henriksen (2006), probably the most cited in the literature. Siau and Long (2005) synthesised five maturity models, including the one by Layne and Lee (2001) to provide a new model with these levels:

1. **Web presence.** All models start with a basic stage where simple and limited information is made accessible through web sites. Baum and Maio (2000) and Siau and Long (2005) call it *web presence*; Deloitte and Touche (2001), Hiller and Bélanger (2001) and Moon (2002) refer to it as *information dissemination* or *one-way communication* and Layne and Lee (2001), as *catalogue*.
2. **Interaction.** Regarded as an intermediate level between web presence and transaction, this level provides simple interaction mechanisms between governments and users, like e-mail request and response systems, or official form downloads, although paperwork is needed to finalise any request within this level. It is also named by some authors as *two-way communication* (Hiller and Bélanger, 2001; Moon, 2002) and is skipped by others, like Deloitte and Touche (2001) and Layne and Lee (2001).
3. **Transaction.** This phase enables users to conduct complete, legally valid, online transactions, without the need of paperwork or in-situ visits.
4. **Transformation.** According to Siau and Long (2005), this stage focuses on transforming the way in which governments provide services. The levels proposed by Layne and Lee (2001), Hiller and Bélanger (2001) and

Moon (2002) of *vertical integration* (integration of government functions at local, sub-national, national and/or international levels) and *horizontal integration* (integration of different departments or government functions at the same level) are included here.

5. **E-democracy.** According to Siau and Long (2005), at this phase, governments attempt to improve political participation, citizen involvement, and political transparencies.

According to Siau and Long (2005), the gaps between the first three levels of maturity are mainly technological, while the achievement of the levels of transformation and e-democracy requires also cultural and political changes. However, financial, legal and organisational barriers to e-government also exist in the first three stages (Coursey and Norris, 2008). The validity of these models is questioned for being mainly conceptual and unsupported by empirical studies (Coursey and Norris, 2008; Shareef et al., 2011). The models predict step-wise, incremental movements of e-government from one stage to the next, but stages can be skipped or mixed. Norris (2010) finds that current e-government development is not leading to e-democracy, as the models predicted.

Even if the models are questionable, it is still possible to apply the concept of maturity level to individual e-government services. Early stages of the models, being more specific in their definitions, provide a useful classification not only for e-government as a whole, but for individual e-government services: informational (web presence), interactive and transactional services. This kind of classification is used, with some differences, in benchmarks like Capgemini et al. (2009, 2010) or in the literature (Coursey and Norris, 2008; Norris, 2010).

### 3. SDIs facilitate E-government services in the environmental domain

#### 3.1. Web presence, interaction and transaction levels

The most basic e-government service consists in providing citizens with access to information (Marchionini et al., 2003). Governments produce huge volumes of information and an increasing amount of this public sector information is now available through the web and other electronic means. SDIs provide a set of standardised, organised core services for searching, accessing and portraying geospatial data associated with the government agency that has the responsibility of creating and maintaining those infrastructures. Regarding this subject, each government agency that has implemented an SDI and a geoportal, is providing implicitly a minimum set of e-government services (Nogueras-Iso et al., 2004). Although this is only an e-government service at the basic level of maturity (*web presence*), its introduction is a clear improvement of the administrative processes: just by making it available to the public through an SDI or through any other mechanism belonging to the *web presence* maturity level, they are complying with the directive on public access to the environmental information and are making data much more useful, as stated by, for instance, the Digital Agenda for Europe (European Commission, 2010d).

When categorising e-government efforts according to their addressees, it is usual to refer to the typology introduced by Brown and Brudney (2001): Government to Citizen (G2C), Government to Business (G2B) and Government to Government (G2G) (Yildiz, 2007), where the additional Intra-government (internal efficiency and effectiveness, IEE) type can be added (E-Government Task Force, 2002). At the basic level of e-government *web presence* service, and taking into account the SDI principle of data sharing in general terms, SDIs can be seen as facilitators for G2C, G2B and G2G relationships using web services. When analysing the INSPIRE directive under this typology, Member State SDIs maintain a G2G relationship with the European SDI, due to the hierarchical development of the latter.

However, a higher level of maturity (*interaction* and *transaction*) in e-government services is desired. In the case of environmental management, where services related to permits require the use of geospatial data in many requests, these e-government levels should be achieved by using SDIs to deal with the geographic information needed for those services. This way, SDI services would provide the base for developing added-value applications that solve real societal issues (Nedović-Budić et al., 2008).

The achievement of the *transaction* stage allows for the elimination of the paperwork and reduces the workload on frontline employees (Layne and Lee, 2001). Additionally, by using e-government tools, users can make use of the official information provided by a given organisation through its own SDI, leading to a much more intensive and automatic exploitation of the information the organisation creates and manages. If the data are integrated into transactional e-government services, the geographical data enclosed within the request by a user can be trusted more: instead of using data from other sources, users will use the same data the organisation is offering as reference or background data, allowing, for instance, for a better provision of locations of elements related to a permit request. Problems derived from using data of different quality or resolution, or even incompatible for any reason (e.g. for being outdated, inaccurate, inconsistent or incomplete) are minimised. As stated by Andersen and Henriksen (2006), in the implementation of e-government applications, governments seek efficiency and effectiveness but also, “data quality improvement gains.” Achieving these levels of maturity mainly addresses G2C and G2B.

### 3.2. Transformation level, integration and cross-border issues

In relation to the *transformation* stage, SDIs also provide the basic artefacts to achieve part of the horizontal and vertical integration levels proposed by Layne and Lee (2001), since the requirements of these levels have been taken into account in the design of the SDIs. To achieve horizontal integration in Europe, under the umbrella of INSPIRE, a set of so-called *implementing rules*<sup>1</sup> have been defined. These implementing rules provide solutions and a common framework for aspects such as harmonisation and interoperability of datasets

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<sup>1</sup><http://inspire.jrc.ec.europa.eu/index.cfm/pageid/47>

and development of common data models, the creation of metadata for discovery, the development of network services, data and service sharing measures, and monitoring and reporting; all this in order to facilitate the sharing of information among EU public authorities, bodies and institutions. In addition to this, the hierarchical design of SDIs provides, in the case of the geospatial information, the basic framework that allows for vertical integration. Seamless sharing of data among different levels (local, sub-national, national, regional) is one of the principles that lay behind the philosophy of the design of SDIs. When discussing about this transformation stage, we are targeting G2G and IEE.

Even though vertical integration and horizontal integration belong to the *transformation* stage, in our opinion, e-government services from the environmental domain have not reached the transaction level yet due to the fact that they involve geospatial information. This makes necessary to first achieve these vertical and horizontal integrations, achievement that can be made by the use of geospatial information through SDIs. This way, any service built on SDIs, either belonging to the web presence, interaction or transaction levels, is contributing to partially achieve the transformation level of e-government, with respect to horizontal and vertical geographical data integration.

But e-government initiatives do not usually take into account any implications of international and cross-border approaches (Capgemini et al., 2009; European Commission, 2010d). Capgemini et al. (2009) questioned to what extend pan-European services are interoperable. According to them, “several contemporary challenges are best addressed by a more pan-European eGovernment approach to service design and delivery”, and among them, environmental management is cited: “Services often delivered by multiple instead of one central service provider, such as [...] ‘environmental permits’ still feature a relatively low usability”, mainly due to the country- or state-oriented approach of these initiatives and despite the means that SDIs offer for achieving horizontal and vertical integration. In *A Digital Agenda for Europe* (European Commission, 2010d), the European Commission shares also this point of view, and observes that “most public online services do not work across borders”. In this sense, as part of this Digital Agenda, the European Commission has launched the *Interoperability Solutions for European Public Administrations* (ISA) programme<sup>2</sup>, that should address this issue by facilitating efficient and effective cross-border electronic collaboration between European public authorities. The European Interoperability Framework (EIF) and the European Interoperability Strategy (EIS) are part of this program (European Commission, 2010a,b). INSPIRE, as a European interoperability directive related to spatial data, is referenced in *Towards interoperability for European public services* (European Commission, 2010c), as an EU interoperability initiative in the environment domain, and in its EIF annex where it is illustrated the *Timeline of EU initiatives concerning interoperability*. However, among the examples of pan-European public services cited in the EIF document, none of them are related to the environment or

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<sup>2</sup>[http://ec.europa.eu/isa/index\\_en.htm](http://ec.europa.eu/isa/index_en.htm)



involve the use of geographical data.

Cross-border interoperability of e-government services that deal with geographic information should not be ignored. In this case, cross-border interoperability is of special importance and poses additional problems. For instance, in order to provide a coherent access and allow for an effective distribution of the data, it is needed to use common data models and harmonise the data. Under the umbrella of the INSPIRE directive, the development of data specifications<sup>3</sup> allows to have directly available common models for a number of themes, since the terms *interoperability* and *harmonisation* mean horizontal, vertical and geographical integration of the spatial datasets of the annexes I, II and III of the INSPIRE directive.

Different policies followed by the different organisations can also be problematic when dealing with cross-border issues of e-government applications: access policies may be different (information that might be public in one country, might not be in the other) or rights, licensing and pricing policies may vary.

Another aspect of a cross-border scenario deals with multilingualism. Multilingual problems may arise at any level of an e-government service: software functionality, web portal contents, documentation, etc. In the case of the spatial data, metadata records, gazetteer applications, toponyms, geoportal contents, user interfaces and legends and labels in digital maps must also be considered. A general solution for this problem includes using multiple-value variables for any of the graphic text components or documents and for each of the different languages; the use of automatic translators when ad-hoc translations are not provided and the use of multilingual thesauri in the annotation and search of resources. But in the case of geographical information, the problem extends to the metadata of datasets and services, on-the-fly generated maps provided by the portrayal services and even their legends. In this case, INSPIRE implementing rules impose some requirements on multilingualism regarding metadata (like the use of a multilingual thesauri like GEMET to tag datasets, or the use of fixed code lists that can be translated in the different EU languages), data specifications (e.g. allowing for toponyms in various languages) and interfaces of web services (to be queried adding a language parameter<sup>4</sup>).

The use of SDIs, together with international agreements can solve the access to cross-border environmental resources. These international agreements, that form part of the development of the SDIs, can be part of the cross-jurisdictional solutions mentioned by Molenaar (2006a), and could be called *geographical integration*. In the next section, we present a concrete application to illustrate the topics discussed here.

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<sup>3</sup><http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2>

<sup>4</sup>Exows (<http://exows.sourceforge.net/>), for instance, is an OGC Web Services wrapper that enables multilingualism functionalities in an INSPIRE compliant way.

#### 4. The case of water abstraction authorisations

In most countries, the use of water (either surface or groundwater) for private purposes requires to obtain an authorisation given by a governmental authority according to certain conditions. Citizens, companies and other organisations are required to apply for obtaining this authorisation, providing certain information in order for the administration to evaluate the request and approve or reject it, based on criteria such as guaranteeing availability in previously authorised abstractions and prioritising some water uses over others (Chang et al., 2010). In Spain, these authorisations are granted by River Basin Authorities, and the process to apply is still paperwork-based, representing however an excellent example of a governmental service that can be provided electronically to the final users.

In this section, an e-government service belonging to the transaction level of maturity in a River Basin Authority in Spain is presented as an example of how SDIs are able to support environment-related e-government services and how they contribute to the achievement of horizontal, vertical and geographical integration. This example was developed in the broader context of an INSPIRE pilot project.

##### 4.1. The Ebro River Basin Authority and the SDIGER pilot

The Ebro River Basin Authority (*Confederación Hidrográfica del Ebro*, CHE) is the Spanish organisation in charge of physically and administratively managing the hydrographical basin of the Ebro River, according to the WFD requirements. Part of its administrative work deals with the analysis and subsequent approval or refusing of the aforementioned water abstractions requests, in conformance with the river basin management plan objectives.

The Ebro basin is a major river basin district in Spain, in the South of the border with France. Although most of the Ebro basin lays in Spanish territory, some streams and river headwaters are across the border, and as it is the case for some parts of the Adour and Garonne river basins, located in the South of France. For instance, the Garonne source is located in Spain and managed by the Ebro River Basin Authority, and the Segre and Irati headwaters, both of them Ebro tributaries, are located in France and managed by the Water Agency for the Adour–Garonne River Basins (*L’Agence de l’Eau Adour–Garonne*) (Fig. 1). The decisions taken by one authority can influence the hydrological management of the other so, in some cases, information related to the territory managed by the other authority should be taken into account. Evidently, in the case of the Ebro River basin, this problem of coordination and information sharing is not as important as in other international river basins, such the Rhine or Danube ones. But cross-border information is still of great importance for each of the Basin Authorities in order to adequately manage the basins.

The issue of providing an internet application for the request of water abstraction permits was first addressed by the SDIGER project (Zarazaga-Soria

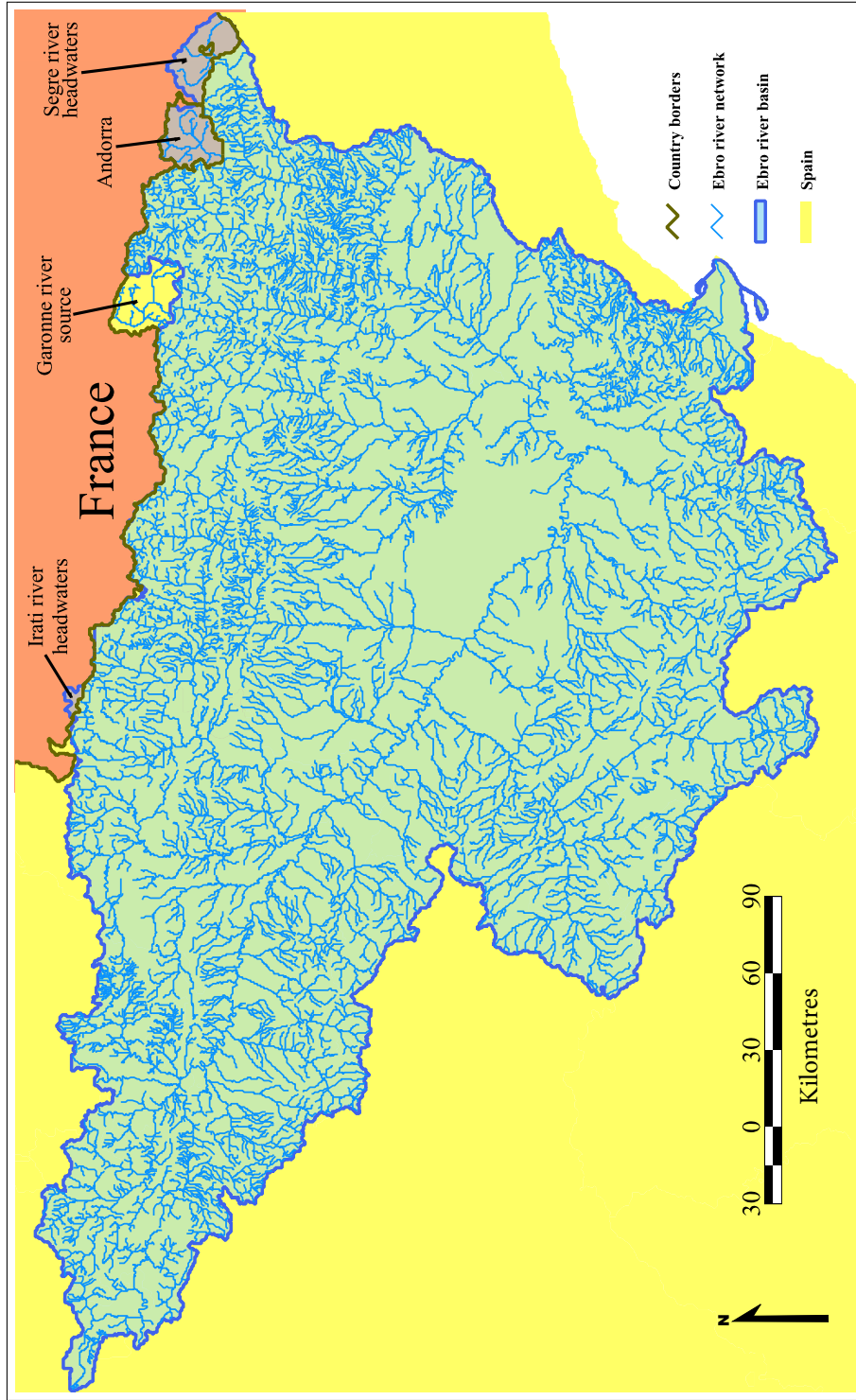


Figure 1: Ebro River basin and network (Geographical coordinates:  $43^{\circ}11'N$  to  $40^{\circ}20'N$   $4^{\circ}24'W$  to  $2^{\circ}9'E$ ). Geographical data provided by the *Confederación Hidrográfica del Ebro*

et al., 2007), a cross-border inter-administration SDI to support WFD information access for Adour–Garonne and Ebro River basins, which was a main pilot project for the INSPIRE Directive.

The SDIGER scenario involved the aforementioned river basin districts at both sides of the border, the Spanish and French Mapping Agencies (*Instituto Geográfico Nacional* and *Institut Géographique National*, respectively), the GIS-ECOBAG association, the French Environment Ministry and the University of Zaragoza, contributing with different SDI services (Fig. 2).

#### 4.2. Paper-based process for requesting water abstractions

Currently, a user applying for obtaining a water abstraction permit must provide information on water use, amount, source (surface or groundwater) and geographical location. A map must be provided, showing the location of the abstraction and discharge points, and the location where water is going to be consumed (a parcel when water is intended for irrigation; a populated place when water is intended for human supply, a factory when the intended use is industrial, etc.) and any other related infrastructure (piping, pumps, etc.) must be provided. This map must be in printed form, being usual that applicants draw by hand the needed elements on an official map of the Spanish Mapping Agency at 1 : 25 000 or 1 : 50 000 scales. There are different administrative processes the request may follow after it is submitted, and the specific one depends mainly on the amount of water requested, but also on the abstraction source and the location. All requests are initially handled by the River Policy Department (*Comisaría de Aguas*) and, in some cases, they are forwarded to the Hydrological Planning Office inside the Ebro River Basin Authority or to other authorities (such as the Spanish Ministry for the Environment or the Adour–Garonne Water Agency). Many of the tasks of the process require loading the information provided by the user in paper form into the information system of the organisation, including the digitalisation of the geographical data provided with the map. Figure 3 shows the process followed by a request using the Business Process Model and Notation (BPMN) (Object Management Group, 2011). The administrative process usually involves a large amount of time. Due to the large number of requests, the users can be waiting more than twelve months to have a response.

As an example of the process, let us consider the case of a farmer who wishes to irrigate a plot of land with an amount of less than 4l/s of surface water directly diverted from the Ebro River. In the first place, the farmer would need to get the forms and instructions for applying for the authorisation. The farmer could ask for them personally in the Ebro River Basin Authority offices or download them from their website. She would fill in her personal data; describe the location of the planned abstraction (river, bank and municipality); indicate the maximum volume of water both in litres per second and in cubic metres per year; the kind of irrigation (spray, sprinkle or drop); the area to be irrigated in hectares; and the kind of crop to be irrigated. She would have to purchase a specific sheet of the map at 1 : 50 000 scale by the Spanish Mapping Agency and draw on it a detailed sketch of the abstraction, the irrigated plot and any other

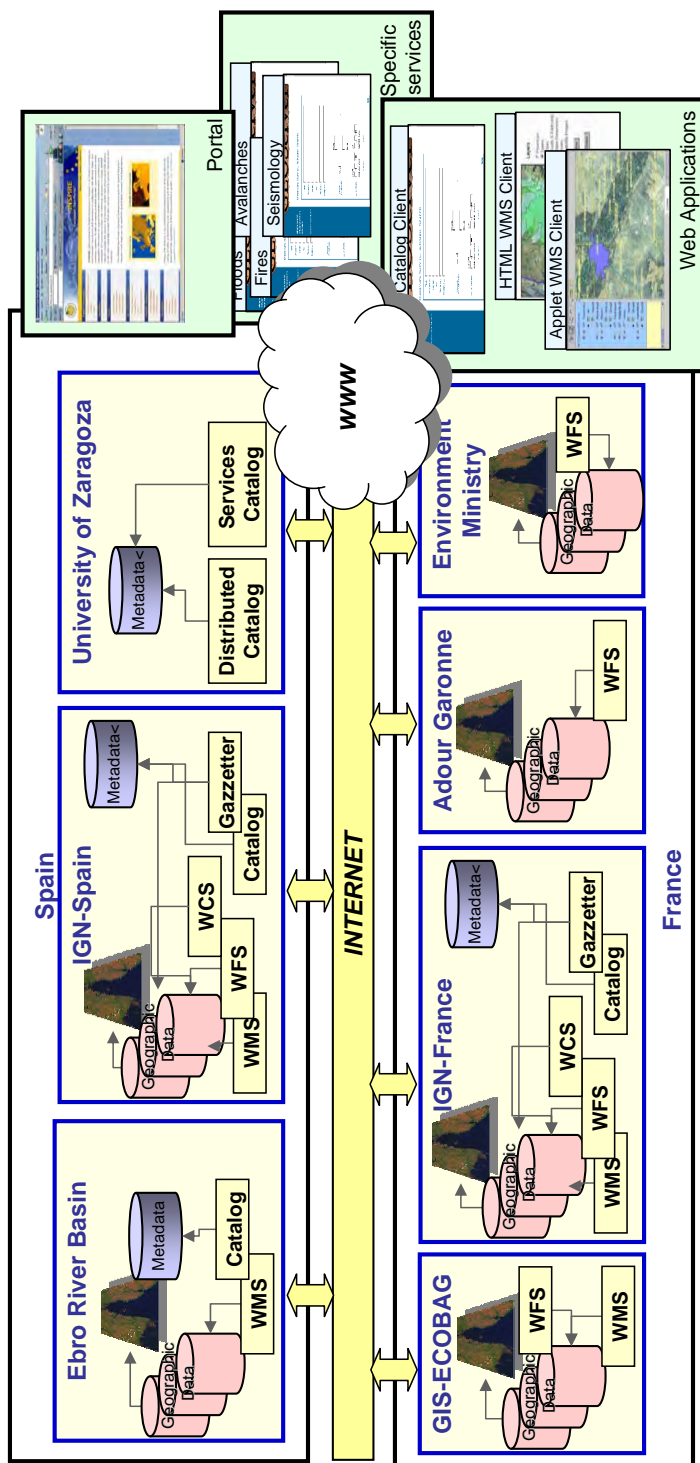


Figure 2: SDI nodes, at partner institutions in the SDIGER pilot

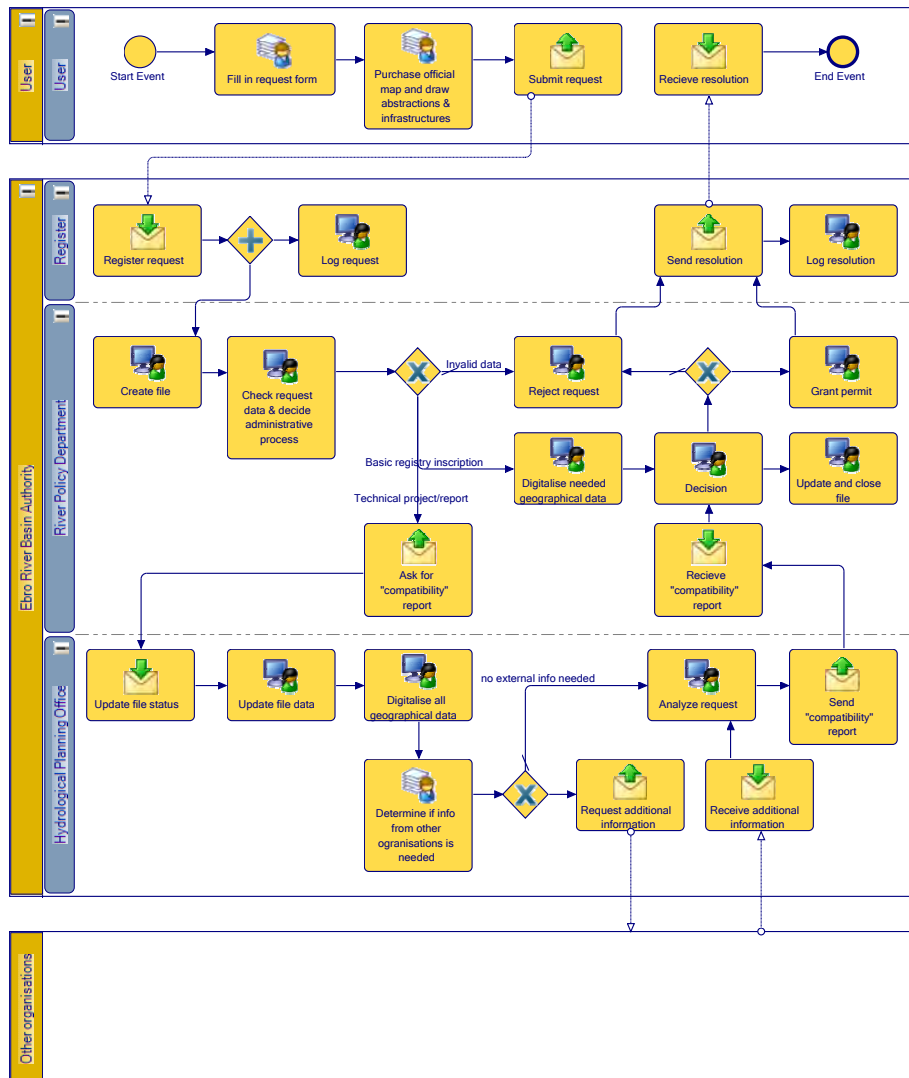


Figure 3: BPMN scheme illustrating the paper-based process for requesting a water abstraction authorisation

required infrastructure (piping, pumps if needed and systems to control the requested volume of water). Next, she would have to include a written report describing the infrastructure works to be carried out and justifying the amount of water requested. She would also have to provide evidence of the ownership of the irrigated area and present a copy of the cadastral map.

Our farmer then should register her paper-based request, either personally in the Ebro River Administration offices or in any other valid registry according to the Spanish law. The request would be initially handled by the River Policy Department, where the data on the request would be checked, and the administrative process would be determined. Given the surface nature of the waters and the amount required (less than 4l/s), a process called *technical report* would be followed. Had the request been of less than 2l/s of groundwater, the process would have been a *basic registry inscription*. Had it been of more than 4l/s, the process would have been a *technical project*, where an engineer would have had to validate the project prior to the submission of the request.

Once the process to be followed had been established as *technical report*, the request would be sent to the Hydrological Planning Office. The information provided by the user in paper form that had not been introduced yet into the information system of the organisation, would then be entered, including the digitalisation of the geographical data provided with the map. The whole information would be analysed, completed and checked, in some cases with data coming from other organisations, and eventually a compatibility report would be generated and sent to the River Policy Department, that would grant or not the permit. The River Policy Department would inform the user, that during the time administrative process had involved would not have had any feedback on the status update of her request.

#### 4.3. The water abstraction e-government service

The main infrastructure in the context of the e-government service described in this section is IDE-Ebro<sup>5</sup>, the initial GIS infrastructure at the CHE, that evolved into an SDI (Carceller-Layel et al., 2009). The mere existence of this SDI implies that a certain level of e-government services, belonging to the most basic levels (web presence, catalogue or simple information dissemination) are being provided, enough to cover, for instance, the requirements of the 14th article of the Water Framework Directive about public information supply, but limited to the Spanish extent of the Ebro basin. IDE-Ebro gives public access to data related to the WFD (surface waters, groundwater bodies and protected areas), their inventory of water points (including wells, springs and monitoring points) and other reference data of the Ebro River basin district. This access is provided through a set of standard web services, such as a catalogue service, web map services, web feature services and a gazetteer service.

Nonetheless, the SDI could be also used to provide the citizens and business with more sophisticated services. In the case of the requests for water

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<sup>5</sup><http://ide-ebro.chebro.es>

abstractions, an e-government service can be provided to achieve the level of transaction, on top of the services provided by the SDI. The involved SDIs, together with the mechanisms derived from the INSPIRE implementation rules, allow for the achievement of some characteristics belonging to the transformation level of maturity: horizontal, vertical and geographical integration.

The e-government service to automate the current paper-based process is provided as a web tool called *Water Abstraction Service*, which is able to coordinate the whole procedure: acquisition and storage of data, generation of a feasibility report, validation of electronic signature and management of user's feedback.

The graphical user interface of the tool enables its users to acquire online the parameters of the request, both non-spatial data (water use, requested amount of water and water abstraction nature: surface or groundwater) and the geographical elements of the request (location of the water abstraction and discharge points, and location where water is going to be used). All this information must be provided by the user, but in the case of the geographical data, it must be supported by the application, by providing the user with a map with tools to select the area where the user wants to apply for an abstraction, to choose the reference data that allow the user to point onto the map the requested locations or draw the perimeter of the irrigation area.

In particular, this geographical data capture component (Figure 4, left) is based on the services provided by SDIs. The location of the area of interest is found by querying gazetteer services from IDE-Ebro and from the Spanish SDI (IDEE<sup>6</sup>), hosted at the Spanish Mapping Agency. These services allow to search for geographical features by name or by zooming in on an interactive map provided by web map services. A visualisation tool allows for the selection of the reference data that is more suitable for the geographical information required (e.g. administrative boundaries, settlements, river network or transport network) and from the most appropriate source: services from the hydrological SDIs (either from IDE-Ebro, or the SDI of the Ministry for the Environment, *Sistema Integrado de Información del Agua*, SIA, or, in the case of border areas, from the SDI of the Adour-Garonne Authority and French Environment Ministry, *Système d'Information sur l'Eau*<sup>7</sup>) or services from mapping agencies SDIs (either from the Spanish or the French ones). Raster images and orthophotos at the appropriate scales are used as background, together with cadastre parcels served by the mapping agencies. Finally, the determination of certain geographic elements that have an impact on the request (e.g. municipalities, river subbasins, hydrogeological domains and aquifers) is done by making requests to web feature services from either the hydrological SDIs or the mapping agencies SDIs.

Data integration in the case of hydrogeological information is much easier when datasets have been designed having a common model, such as is the

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<sup>6</sup><http://www.idee.es>

<sup>7</sup><http://adour-garonne.eaufrance.fr/>



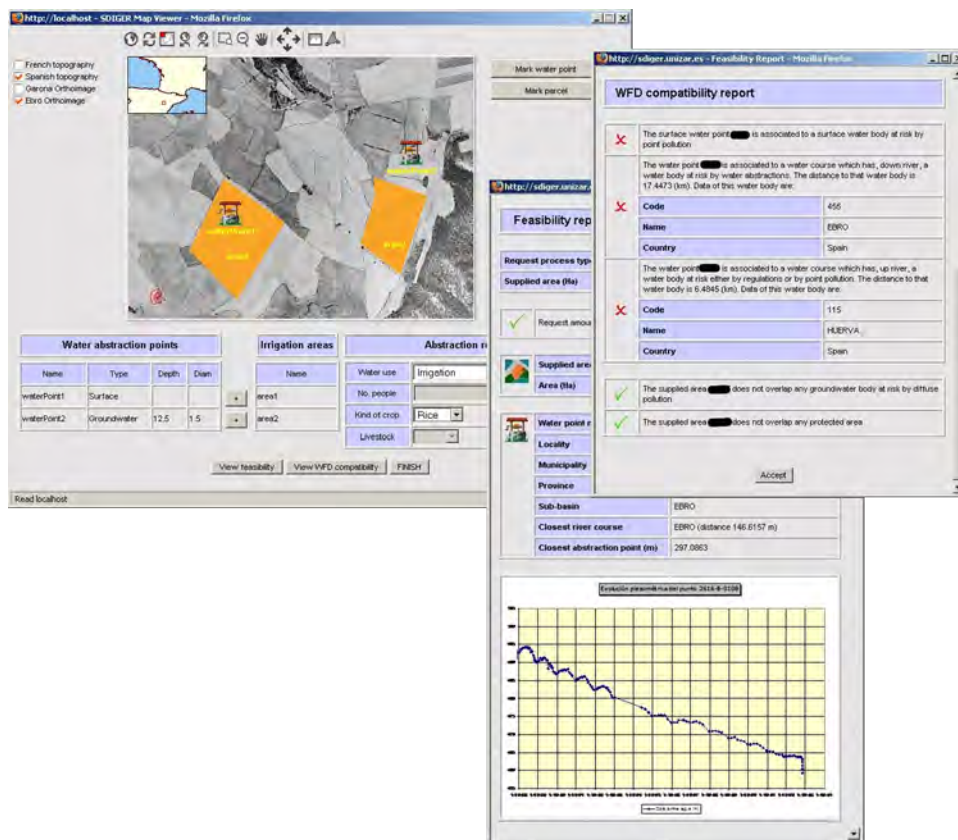


Figure 4: Graphic user interface of the water abstraction e-government service

case of the layers related to the Water Framework Directive, of which the first model was proposed by Vogt (2002), even if this basic model is customised by the involved agencies to adapt it to their particular needs. In this case, the requirements posed by an environmental directive led to the desired data integration. In other cases, e.g. the layers related to hydrography, the datasets to be harmonised have been designed differently and are therefore different in their structure and content. The problems that arise in this case, such as semantic difficulties in the understanding of the concepts modelled by the data; make necessary to have a common data model. In the case of hydrography data, the INSPIRE *Data Specification on Hydrography* (INSPIRE Thematic Working Group Hydrography, 2010) can be used.

Data obtained during the request is included into the information systems of the Ebro River Basin Authority and it is used to provide the user with a feasibility report and information on the administrative process that will be followed (Figure 4, right).

Without any tools for electronic signature, the application presented so far can be used just to help the user to generate the documentation and paperwork needed to submit the request in a traditional way, resulting the provided electronic service in a *web presence* or just *interactive* e-government service. The achievement of a full transactional service is obtained by the integration of an electronic signature applet that administratively formalises the whole process by using a certification tool (digital certificate or electronic identity card).

Finally, some services and functionality are included in the infrastructure in order to provide a globally positive user experience by increasing usability (help functionality and process tracking) and user satisfaction monitoring (user feedback and reporting) (Verdegem and Verleye, 2009). Regarding process tracking, users are informed about the administrative status and updates of their requests as they are processed. These administrative statuses can be consulted via web (once the user has been authenticated) and updates on the status can be sent to the user's e-mail or mobile phone.

#### 4.4. E-government process for requesting water abstractions

Figure 5 reflects the modified process the requests follow once a transactional level e-government service is in use. The submission of the request is done through an information system, instead of the paperwork, so the tasks of registering, logging the request and storing digital data (including geographical data) can be fully automated, reducing the workload of the organisation staff. In addition to this, clearly non-valid requests can be rejected automatically, and valid requests with a low probability of being granted can be reworked before submission (by, for instance, reducing the amount of requested water). This way, the number of requests that are submitted but eventually rejected is reduced.

In this case, our farmer of section 4.2 would have been able to fill online the data of her request. Instead of purchasing a copy of the map by the Mapping Agency, she would have located her area of interest in the map provided by the tool, either by zooming in or by using the gazetteer service. She also would have had to draw the irrigated area and the rest of the infrastructure related

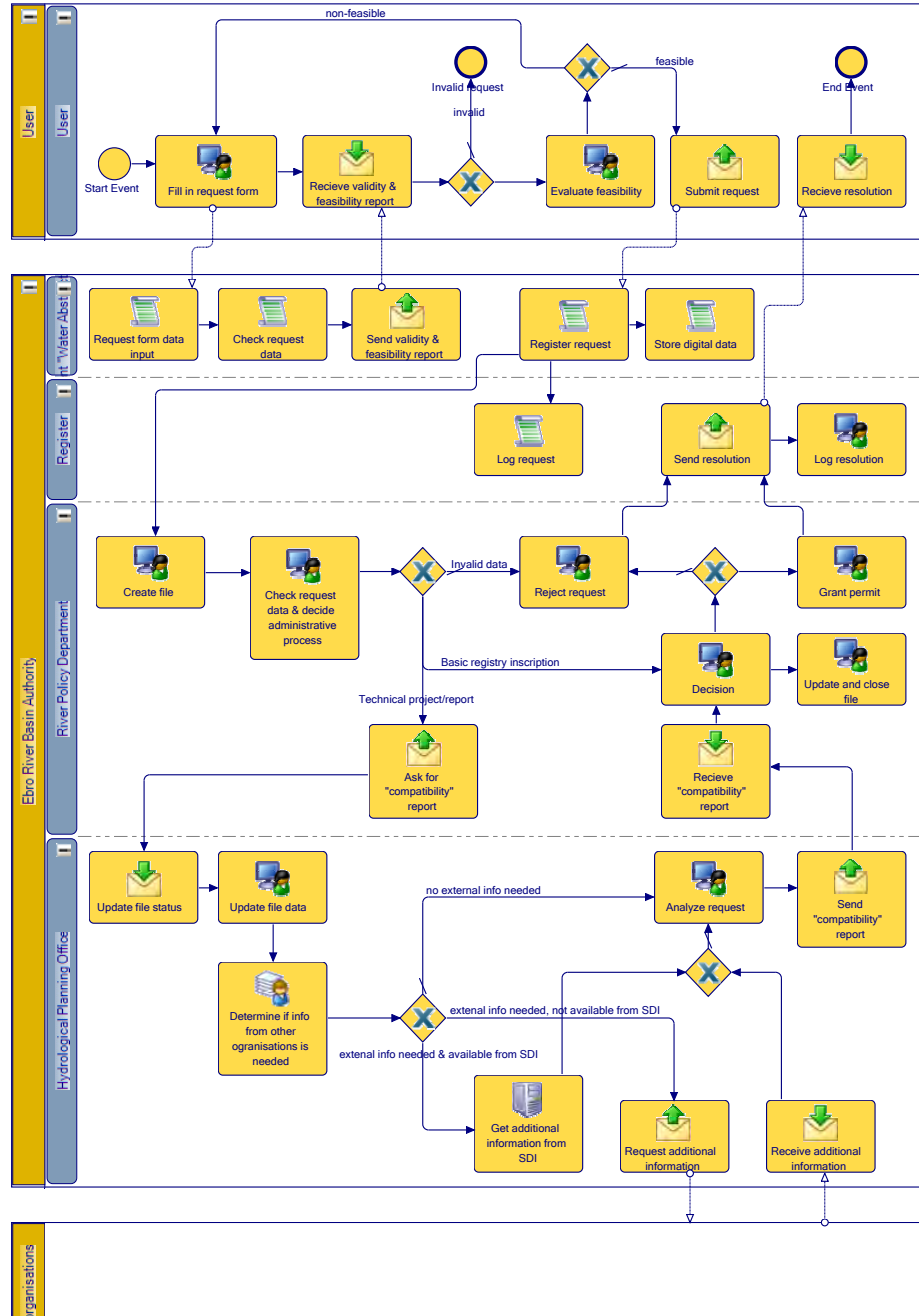


Figure 5: BPMN scheme illustrating the process for requesting a water abstraction authorisation using the transaction water abstraction e-government service shown in Figure 4

to the request, but instead of having to do so over the information provided by the official map, here she would have had options to show or hide layers of data, including orthoimagery and cadastral parcels, making the drawing easier for her. Some redundant data she would have had to provide with the paper-based process, such as river, bank, municipality and area of the irrigation plot, could now be derived from the geographical data she would be inserting into the system.

Once the farmer would have input the required information into the system, a first feedback about her request could be provided. The system could point out mistakes or explain the reasons why the request would be automatically rejected (like, for instance, requesting too much water than really needed for the kind of crop and the irrigated area). Such problems could be corrected before the submission was made. The system could also inform her about the feasibility of her request being granted. For instance, the probability of the permit being granted could be low due to the fact that water availability could not be guaranteed. That would allow her for reworking it (by, for instance, changing the kind of crop for other less water-demanding or by reducing the area to be irrigated) before officially submitting the request.

The presented service, being a G2C example, radically changes the front office, but is quite conservative in terms of modifications to the back office process: initial handling is still done by the River Policy Department, some request requiring a compatibility report are still forwarder to the Hydrological Planning Office, and so on. However, it offers an opportunity to address IEE by improving the overall process by, for instance, automating the opening of the file or delivering it directly to the appropriate department. Additionally, G2G relations are established when additional data from other organisations is needed. The process of requesting these data can be simplified if the other organisations also operate e-government together with SDI services (as regarded by Crompvoets et al., 2011). For instance, checking whether the irrigated area associated with a request falls into a single cadastral parcel or spreads across several ones becomes easier if cadastral geographical data is offered online through an SDI. The farmer of our example would no longer need to prove the ownership of the irrigated area nor present a copy of the cadastral map.

## 5. Conclusions

Spatial Data Infrastructures have revolutionised the domain of geospatial information, that is related to most of the information used by public authorities. Having interoperable and harmonised environmental data is considered so important that there exists a directive, INSPIRE, created with the political leadership of the EU Environment Directorate-General, aiming specifically at establishing a European SDI as a means to achieve the above.

SDIs can be considered an interesting framework to support environment-related e-government services, allowing to reach a significant level in e-government maturity models. The many initiatives and legal obligations to build SDIs,

support by themselves e-government services at the level of *diffusion of information*. In addition to that, SDI principles, combining spatial data from different sources in a consistent way and sharing among several users and applications, have led to a set of implementations rules that ensure horizontal, vertical and geographical integration of geospatial data. In this way, SDIs can also be used as a base for the development of e-government services at the maturity levels of *interaction* and *transaction*.

In the case of e-government services related to geographical information, the stages of vertical and horizontal integration proposed by, for instance, Layne and Lee (2001) are not really stages *after* the transaction level, but requirements to achieve the levels of interaction and transaction. This way, any service built on SDIs is contributing to partially achieve the *transformation* level of e-government, with respect to horizontal and vertical geographical data integration. An additional kind of integration, *geographical integration* (integration of information through neighbour organisations) can be identified in this case.

This paper has also presented, as a proof-of-concept, a real application in the area of the environment-related permits: the process of applying for a water abstraction authorisation. The application was built as part of SDIGER, a cross-border inter-administration SDI to support water framework directive information access for Adour-Garonne and Ebro River basins, a pilot project for the European INSPIRE Directive. In this example, SDI services are used for the capture, management, and assessment of geographical information in a transactional level e-government service, where it is necessary to access data and services from different providers, and from different themes. The use of the SDIs maintained by the different authorities involved allows to integrate data and services in the hydrological domain between the main provider, a river basin authority, and the ministry this authority depends on (*vertical integration*). It also integrates data and services in other domains (orthoimagery or cadastre, for example) between the authority and a mapping agency (*horizontal integration*), and data and services with neighbouring water agencies (*geographical integration*).

The introduction of a transactional level e-government service modifies the administrative process of granting authorisations. The tasks of entering data (including geospatial data) are performed directly by the applicant, and the official registration of the request is performed automatically. An automated report can be provided to prevent the user from applying for either invalid or non-feasible requests, reducing thus the staff workload.

We think that this architectural strategy based on SDIs may open a promising approach to facilitate the development of higher-level e-government services in the environmental management domain.

We are considering two different lines of future work. On the one hand, we will continue analysing the relation between e-government and SDIs in the environmental domain. Other administrative processes from the Ebro River Basin Authority, such as water dumping permits, the complementary authorisation to the one presented here, will be examined, and proposals of new services will be made. On the other hand, we have already modelled SDIs as federations of

autonomous communities (Béjar et al., 2012) following the enterprise language of the *Reference Model of Open Distributed Processing* (RM-ODP) (ISO/IEC, 2006). We are working in analysing the INSPIRE directive in terms of an architectural viewpoint built upon the concepts of the enterprise language of the RM-ODP standard and its extrapolation to other e-government initiatives, as a first step to design information systems that comply with certain laws.

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#### *Note*

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